

APPENDIX 1
SUPPLEMENTAL STATISTICAL ANALYSES

We also conducted a more rarefied analysis using eight taxonomically grouped categories – Modern avian melanosomes ($n = 1309$), Modern anuran melanosomes ($n = 212$), Microbodies from isolated fossil feathers ($n = 336$), Microbodies from fossil birds and dinosaurs ($n = 411$), Microbodies from fossil anurans ($n = 180$), Microbial consortia from isolated feather decay ($n = 482$), Microbial consortia from avian carcass decay ($n = 1355$), and Microbial consortia from tadpole decay ($n = 280$). The datasets, as per adopted statistical protocol, were first standardised, and the residuals were examined for normality using the Kolmogorov-Smirnov (KSL) and Shapiro-Wilk (S-W) goodness-of-fit tests (Yap and Sim, 2011). Secondly, since the residuals for all three categories have significant departures from normality ($p < 0.001$), non-parametric Wilcoxon/Kruskal-Wallis tests (Lehmann and D'Abrera, 1975) were conducted which showed significance for length, ($\chi^2 = 2335.4521$, $p < 0.0001$), diameter ($\chi^2 = 1283.8161$, $p < 0.0001$) and aspect ratio ($\chi^2 = 943.9720$, $p < 0.0001$) of comparing medians were opted for, followed by multiple comparisons using the Steel-Dwass method (Neuhäuser and Bretz, 2001). The multiple comparisons are addressed in Table S1. PCA score plot for the rarefied taxonomic categories is shown in Figure S1. Additionally, PCA was also applied to summary statistics for length, diameter, and aspect ratio to determine if these parameters frequently used in quadratic discriminant analyses for fossil colour reconstruction, can actually distinguish between modern melanosomes, fossil microbodies and decay-associated microbial consortia (Figure S2). It seems that using summary values (means, maxima and minima), the separation becomes even more clear.

TABLE S1
MULTIPLE PAIRWISE COMPARISONS USING THE STEEL-DWASS METHOD

Variable	Level 1	Level 2	Score Mean Difference	Standard Error Difference	Z	p-Value	Hodges-Lehmann Statistics	Lower CL	Upper CL
Length	Avian carcass decay bacteria	Modern avian melanosomes	790.3715	29.8094	26.5142	5.70988×10^{-13}	0.561	0.498	0.626
	Avian carcass decay bacteria	Modern anuran melanosomes	663.2993	33.4206	19.8470	5.70988×10^{-13}	0.799	0.695	0.911
	Avian carcass decay bacteria	Microbodies from fossil anurans	656.9850	35.1647	18.6831	5.70988×10^{-13}	0.854	0.743	0.976
	Avian carcass decay bacteria	Microbodies from isolated fossil feathers	466.7595	29.7587	15.6848	5.70988×10^{-13}	0.466	0.376	0.563
	Microbodies from fossil birds and dinosaurs	Modern avian melanosomes	314.7462	28.0826	11.2079	5.70988×10^{-13}	0.254	0.189	0.319
	Avian carcass decay bacteria	Microbodies from fossil birds and dinosaurs	301.1655	28.7162	10.4876	5.70988×10^{-13}	0.317	0.224	0.415
	Isolated feather decay bacteria	Modern avian melanosomes	291.2804	27.5537	10.5714	5.70988×10^{-13}	0.239	0.17	0.31
	Avian carcass decay bacteria	Isolated feather decay bacteria	281.5607	28.1318	10.0086	5.70988×10^{-13}	0.305	0.214	0.397
	Isolated feather decay bacteria	Microbodies from fossil anurans	260.5805	16.7057	15.5983	5.70988×10^{-13}	0.534	0.451	0.624
	Isolated feather decay bacteria	Modern anuran melanosomes	256.2905	16.5222	15.5118	5.70988×10^{-13}	0.479	0.4	0.563
	Microbodies from fossil birds and dinosaurs	Modern anuran melanosomes	226.5393	15.2195	14.8848	5.70988×10^{-13}	0.54	0.455	0.62
	Microbodies from isolated fossil feathers	Modern anuran melanosomes	191.8177	13.8879	13.8118	5.70988×10^{-13}	0.36	0.295	0.423
	Tadpole decay bacteria	Microbodies from fossil anurans	176.6482	12.6999	13.9094	5.70988×10^{-13}	0.459	0.365	0.566
	Tadpole decay bacteria	Modern anuran melanosomes	172.9625	12.9434	13.3630	5.70988×10^{-13}	0.4	0.313	0.501

	Microbodies from fossil anurans	Microbodies from isolated fossil feathers	-201.0037	13.7720	-14.5951	5.70988×10^{-13}	-0.419	-0.484	-0.352
	Microbodies from fossil anurans	Microbodies from fossil birds and dinosaurs	-228.2196	15.2616	-14.9539	5.70988×10^{-13}	-0.601	-0.685	-0.514
	Tadpole decay bacteria	Avian carcass decay bacteria	-311.6196	30.9934	-10.0544	5.70988×10^{-13}	-0.374	-0.487	-0.265
	Modern anuran melanosomes	Modern avian melanosomes	-358.4661	32.5168	-11.0240	5.70988×10^{-13}	-0.277	-0.342	-0.21
	Microbodies from fossil anurans	Modern avian melanosomes	-416.9162	34.1815	-12.1971	5.70988×10^{-13}	-0.336	-0.406	-0.265
	Microbodies from fossil birds and dinosaurs	Microbodies from isolated fossil feathers	109.7976	15.8705	6.9184	1.28413×10^{-10}	0.179	0.103	0.253
	Tadpole decay bacteria	Modern avian melanosomes	186.0871	30.2122	6.1593	2.04209×10^{-8}	0.17	0.085	0.257
	Isolated feather decay bacteria	Microbodies from isolated fossil feathers	91.9210	16.7923	5.4740	1.22373×10^{-6}	0.143	0.063	0.228
	Microbodies from isolated fossil feathers	Modern avian melanosomes	116.2545	29.0503	4.0018	0.00161776	0.081	0.02	0.142
	Microbodies from fossil anurans	Modern anuran melanosomes	-36.3237	11.4837	-3.1631	0.033556014	-0.054	-0.104	-0.003
	Tadpole decay bacteria	Microbodies from isolated fossil feathers	36.0185	14.4007	2.5012	0.194724264	0.073	-0.016	0.167
	Tadpole decay bacteria	Microbodies from fossil birds and dinosaurs	-34.9613	15.4682	-2.2602	0.315879794	-0.079	-0.181	0.027
	Tadpole decay bacteria	Isolated feather decay bacteria	-35.3249	16.5395	-2.1358	0.391650737	-0.072	-0.174	0.03
	Isolated feather decay bacteria	Microbodies from fossil birds and dinosaurs	-4.6836	17.3175	-0.2705	0.999994835	-0.009	-0.101	0.085
Width	Avian carcass decay bacteria	Modern avian melanosomes	1127.5682	29.8093	37.8261	5.70988×10^{-13}	0.267	0.249	0.285
	Isolated feather decay bacteria	Modern avian melanosomes	797.6226	27.5536	28.9481	5.70988×10^{-13}	0.235	0.218	0.253
	Tadpole decay bacteria	Modern avian melanosomes	730.6248	30.2120	24.1833	5.70988×10^{-13}	0.225	0.208	0.243
	Avian carcass decay bacteria	Microbodies from isolated fossil feathers	721.8451	29.7586	24.2567	5.70988×10^{-13}	0.257	0.23	0.284
	Microbodies from fossil anurans	Modern avian melanosomes	685.8013	34.1812	20.0637	5.70988×10^{-13}	0.234	0.211	0.258
	Modern anuran melanosomes	Modern avian melanosomes	610.4597	32.5165	18.7738	5.70988×10^{-13}	0.214	0.193	0.235
	Microbodies from fossil birds and dinosaurs	Modern avian melanosomes	467.7306	28.0824	16.6557	5.70988×10^{-13}	0.118	0.098	0.139
	Avian carcass decay bacteria	Microbodies from fossil birds and dinosaurs	433.4399	28.7162	15.0939	5.70988×10^{-13}	0.148	0.119	0.176
	Isolated feather decay bacteria	Microbodies from isolated fossil feathers	374.9318	16.7922	22.3277	5.70988×10^{-13}	0.222	0.199	0.246
	Tadpole decay bacteria	Microbodies from isolated fossil feathers	294.6298	14.4005	20.4596	5.70988×10^{-13}	0.21	0.191	0.23
	Microbodies from fossil anurans	Microbodies from isolated fossil feathers	246.1281	13.7718	17.8719	5.70988×10^{-13}	0.22	0.194	0.246
	Isolated feather decay bacteria	Microbodies from fossil birds and dinosaurs	211.5253	17.3174	12.2146	5.70988×10^{-13}	0.121	0.092	0.148
	Microbodies from fossil birds and dinosaurs	Microbodies from isolated fossil feathers	194.9180	15.8702	12.2820	5.70988×10^{-13}	0.106	0.081	0.132

	Tadpole decay bacteria	Microbodies from fossil birds and dinosaurs	164.3887	15.4681	10.6276	5.70988×10^{-13}	0.108	0.08	0.138
	Microbodies from fossil anurans	Microbodies from fossil birds and dinosaurs	146.2801	15.2615	9.5849	5.70988×10^{-13}	0.119	0.083	0.154
	Microbodies from isolated fossil feathers	Modern anuran melanosomes	-222.6481	13.8877	-16.0320	5.70988×10^{-13}	-0.201	-0.224	-0.179
	Microbodies from fossil birds and dinosaurs	Modern anuran melanosomes	-114.2510	15.2194	-7.5069	2.26086×10^{-12}	-0.088	-0.121	-0.054
	Avian carcass decay bacteria	Modern anuran melanosomes	182.4094	33.4205	5.4580	1.33875×10^{-06}	0.065	0.029	0.1
	Tadpole decay bacteria	Avian carcass decay bacteria	-118.4599	30.9933	-3.8221	0.003321091	-0.039	-0.071	-0.008
	Microbodies from isolated fossil feathers	Modern avian melanosomes	91.4238	29.0500	3.1471	0.035250758	0.015	0.001	0.029
	Avian carcass decay bacteria	Isolated feather decay bacteria	83.5568	28.1317	2.9702	0.059585792	0.026	-0.001	0.053
	Isolated feather decay bacteria	Modern anuran melanosomes	44.5941	16.5221	2.6991	0.12271801	0.028	-0.004	0.061
	Avian carcass decay bacteria	Microbodies from fossil anurans	79.2045	35.1646	2.2524	0.320400409	0.028	-0.01	0.067
	Microbodies from fossil anurans	Modern anuran melanosomes	23.9093	11.4837	2.0820	0.426588433	0.024	-0.01	0.06
	Tadpole decay bacteria	Modern anuran melanosomes	17.1031	12.9433	1.3214	0.891036165	0.012	-0.015	0.04
	Tadpole decay bacteria	Isolated feather decay bacteria	-16.8283	16.5394	-1.0175	0.971982126	-0.009	-0.036	0.017
	Tadpole decay bacteria	Microbodies from fossil anurans	-11.0254	12.6997	-0.8682	0.98880712	-0.009	-0.038	0.021
	Isolated feather decay bacteria	Microbodies from fossil anurans	0.8737	16.7055	0.0523	1	0.001	-0.032	0.034
Aspect Ratio	Avian carcass decay bacteria	Microbodies from fossil anurans	619.1324	35.1647	17.6066	5.70988×10^{-13}	1.5695	1.3148	1.8474
	Avian carcass decay bacteria	Modern anuran melanosomes	544.7406	33.4206	16.2996	5.70988×10^{-13}	1.3483	1.1106	1.6088
	Isolated feather decay bacteria	Microbodies from fossil anurans	238.0217	16.7057	14.2479	5.70988×10^{-13}	1.0723	0.8481	1.3247
	Microbodies from isolated fossil feathers	Modern anuran melanosomes	230.1297	13.8880	16.5704	5.70988×10^{-13}	2.3273	2.0790	2.5800
	Microbodies from fossil birds and dinosaurs	Modern anuran melanosomes	218.6528	15.2195	14.3666	5.70988×10^{-13}	1.7589	1.5068	2.0104
	Isolated feather decay bacteria	Modern anuran melanosomes	198.6665	16.5223	12.0242	5.70988×10^{-13}	0.8612	0.6445	1.1013
	Tadpole decay bacteria	Microbodies from fossil anurans	173.9010	12.7000	13.6930	5.70988×10^{-13}	1.0000	0.7963	1.2014
	Tadpole decay bacteria	Modern anuran melanosomes	151.4997	12.9435	11.7047	5.70988×10^{-13}	0.8010	0.6030	1.0056
	Tadpole decay bacteria	Microbodies from fossil birds and dinosaurs	-136.2365	15.4682	-8.8075	5.70988×10^{-13}	-0.9230	-1.2090	-0.6254
	Tadpole decay bacteria	Microbodies from isolated fossil feathers	-197.1521	14.4007	-13.6904	5.70988×10^{-13}	-1.4849	-1.7555	-1.2087
	Isolated feather decay bacteria	Microbodies from isolated fossil feathers	-229.2897	16.7923	-13.6544	5.70988×10^{-13}	-1.3856	-1.6453	-1.1221
	Microbodies from fossil anurans	Microbodies from isolated fossil feathers	-237.2295	13.7720	-17.2254	5.70988×10^{-13}	-2.5494	-2.7959	-2.2851
	Microbodies from fossil anurans	Microbodies from fossil birds and dinosaurs	-242.2836	15.2616	-15.8754	5.70988×10^{-13}	-1.9727	-2.2357	-1.7132

Avian carcass decay bacteria	Modern avian melanosomes	-268.2774	29.8094	-8.9998	5.70988×10 ⁻¹³	-0.6187	-0.8291	-0.4109
Avian carcass decay bacteria	Microbodies from isolated fossil feathers	-269.1828	29.7587	-9.0455	5.70988×10 ⁻¹³	-0.8584	-1.1127	-0.5917
Isolated feather decay bacteria	Modern avian melanosomes	-365.3304	27.5537	-13.2588	5.70988E-13	-1.1598	-1.4306	-0.8990
Tadpole decay bacteria	Modern avian melanosomes	-367.7500	30.2122	-12.1722	5.70988E-13	-1.2595	-1.5905	-0.9475
Modern anuran melanosomes	Modern avian melanosomes	-567.2618	32.5168	-17.4452	5.70988E-13	-2.0295	-2.4077	-1.7221
Microbodies from fossil anurans	Modern avian melanosomes	-628.3761	34.1815	-18.3835	5.70988E-13	-2.2800	-2.6888	-1.9465
Isolated feather decay bacteria	Microbodies from fossil birds and dinosaurs	-146.4284	17.3175	-8.4555	5.71654E-13	-0.8142	-1.0912	-0.5317
Tadpole decay bacteria	Avian carcass decay bacteria	-222.3324	30.9935	-7.1735	2.10139E-11	-0.5749	-0.8325	-0.3306
Avian carcass decay bacteria	Isolated feather decay bacteria	201.2104	28.1318	7.1524	2.44209E-11	0.5009	0.2896	0.7163
Microbodies from fossil birds and dinosaurs	Microbodies from isolated fossil feathers	-87.4627	15.8705	-5.5110	9.92611E-07	-0.5638	-0.8665	-0.2593
Microbodies from fossil anurans	Modern anuran melanosomes	-61.7225	11.4839	-5.3747	2.13001E-06	-0.1733	-0.2684	-0.0796
Microbodies from fossil birds and dinosaurs	Modern avian melanosomes	-109.7381	28.0826	-3.9077	0.002368738	-0.3880	-0.7048	-0.0866
Avian carcass decay bacteria	Microbodies from fossil birds and dinosaurs	-89.7912	28.7163	-3.1268	0.037514913	-0.2765	-0.5365	-0.0082
Microbodies from isolated fossil feathers	Modern avian melanosomes	47.4249	29.0503	1.6325	0.7305783	0.1696	-0.1489	0.4768
Tadpole decay bacteria	Isolated feather decay bacteria	-15.2360	16.5396	-0.9212	0.98412526	-0.0721	-0.3207	0.1614

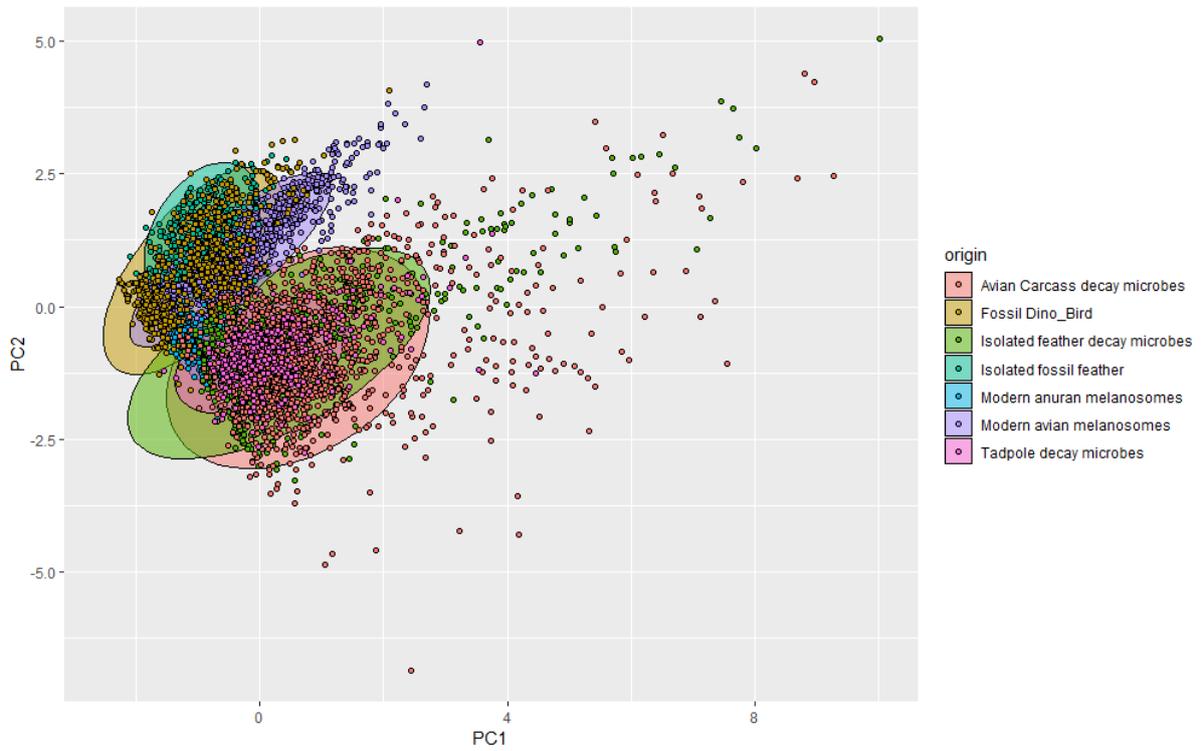


Fig. S1. PCA plot with PC1 and PC2 as axes for taxonomically grouped categories. 95% confidence intervals shown by coloured ellipses.

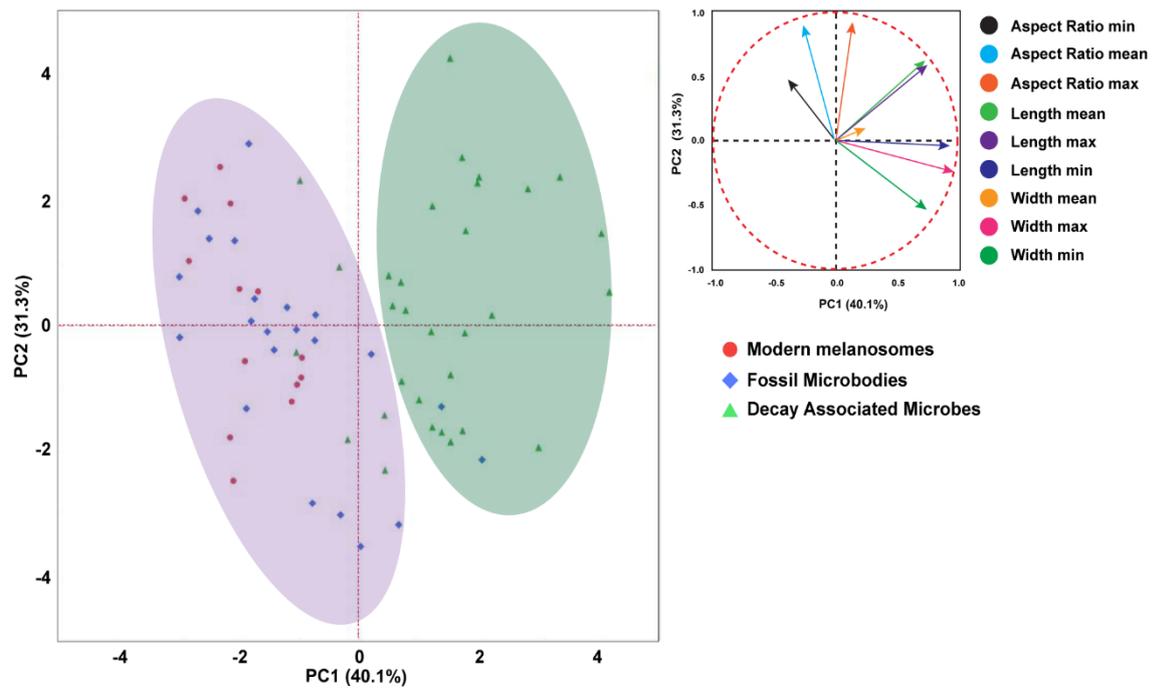


Fig. S2. Principal components analysis (PCA) shows the percent of variation accounted for by each component axes. The purple ellipse indicates closely associated modern melanosomes and fossil microbodies whereas the green ellipse indicates decay associated microbes. Clear separation is seen between modern melanosomes-fossil microbodies and decay associated microbes.